2015 Honeywell Users Group
Europe, Middle East and Africa

Ensuring APC Optimization with Profit Suite

Richard Salliss, Honeywell
Profit Optimization Suite

Profit Controller

Past

Future

Optimal Response

Predicted Unforced Response

Setpoint

Assumed Values

CV

MV

Control Performance Monitor

Profit Sensor Pro

Profit Stepper

Optimum *

Optimum Profit Optimizer: Real-time, Dynamic Optimal Response

Real-time, Dynamic

Profit

Current Operation

Additional $ Benefits

Wait for Steady State

Steady-State Optimization

Time
Profit Optimization Suite

• One Consistent technology platform
  – MPC and Real Time Optimization
  – Flexible Modeling environment
  – Unmatched operational awareness
  – Lowest lifecycle cost

Profit Loop → Experion Profit Controller (C300/ACE) → Profit Suite - Profit Controller - Profit Sensor - Profit Stepper → Profit Optimizer (DQP Multi-Unit Optimization) → Profit Executive (SuperDQP Multi-Asset Optimization)

Continuum of Control Solutions

Single Variable Linear Control → Seconds → Profit CPM (Control Performance Monitor) → Multiple-Variable Non-Linear Control and Optimization → Hours/Days
Profit Suite R431 – Proposed Scope

- CAB Prioritized enhancements
- Profit Suite Engineering Studio
  - Profit Optimizer integration
  - Enhanced DMCplus conversion tools
  - Support for Predict Back
- Updated CV Move Function Block (account for subcontrollers)
Profit Suite R440 – Proposed Scope

• Platform & Infrastructure Compliance
• Profit Optimizer Enhancements
  – APC Vendor Agnostic
  – Operator Guidance for optimization
• Honeywell User Experience
  – Engineer/Operator Feedback
  – CAB Prioritized enhancements
• APC monitoring / benefits sustainment improvement
  – Improved support for BGP Performa
  – Mobility and alignment with CPM and BGP Performa
• Operator Training Tools
  – Automate/simplify model builds for USO training infrastructure
Most APC applications have two components
  – Constraint control
  – Optimization

Key to successful application
  – Design for responsive control action
  – Use optimizer to take economic advantage of degrees of freedom

Small scope applications are straightforward
  – Distillation column, reactor, furnace
  – Good control and Opt scope inherent
  – Few design issues

Large scope Applications are more challenging
  – Multiple columns, Multiple equipment processing unit
  – Trade off typically requires choosing either good control or optimization scope
Traditional Optimization Overview

- Build SS model for Optimizer
  - Linear, NL, large scale
  - Represents plant behavior
  - Define objective function

- Calculate SS targets to determine the end goal

- Realize the operating value by dealing with dynamics
  - Ensure feasibility
  - Prevent constraint violations
  - Push plant to SS

- Update the model, objective function and dynamic compensator
  - Compensate for changing conditions

- Repeat cycle

Without Profit Optimization, the LP Override must be engineered to provide feasible SS controller targets and a realistic ramp rate to the MPC controller.
Solving The Dilemma

• Profit Optimization Suite provides best of both big and multiple small applications
  – Model pairing for good local control
  – Global objective function to fully utilize degrees of freedom
  – Reduce impact of week and less certain models

• A robust solution
  – Flexes with changing process conditions
    • Accepts what can realistically be achieved and rejects what can’t
  – Ensures feasible optimization path across entire process scope

• Easy-to-use optimization/coordination solution
  – Accommodates both SS and dynamic optimization schemes
Honeywell’s Layered Optimization

- Dynamic application
- Multi-unit optimization
- Non-linear optimization

Profit Optimizer

Profit Optimizer coordinates the economics of multiple Profit Controllers for multi-unit plant-wide optimization

Economics and Ideal Target Values

Control Variables

Product Value Optimization

RMPCT Algorithm

Manipulated Variables

Disturbance Values
Profit Optimizer

SS Model

Profit Bridge

Gains

Global Economics and Ranges

Limits

SS MV Targets
Gains
MV Economics

Profit Optimizer

QP Override 1

QP Override 2

QP Override 3

Local Feasible SS MV targets

Profit Controller 1

Profit Controller 2

Profit Controller 3

Process 1

Process 2

Process 3

Interface block

Other Controller 2

Feedback

Ensures Optimal Dynamic Global Path
20-30% additional benefits over unit-based optimization
R440 Optimization Enhancements

- Profit Optimizer will be enhanced to include ‘Hessian Updating’ which will
  - allow optimizer to use ‘rate-of-change’ information compared to simple gain updating
  - allow faster convergence on the optimum solution and improved ability to deal with process non-linearities
  - provide additional benefits of around 10%, depending on process non-linearities

- Profit Optimizer will be deployable across all major APC solutions on the market, not just Profit Controller
Plant-wide Optimization

Key Challenge: How to get the solution layers to stay consistent and reach the global optimum jointly?

Business Planning
- Plantwide economics
- Production Planning

Schedule & Optimization

Optimal feasible

Control & Optimization
- Local economics

How to get the solution layers to stay consistent and reach the global optimum jointly?

Integration Scheme? How?

- Manage intermediate and final:
  - Inventory (volumes)
  - Properties (quality)
  - Timeline (just in time)

Planning (Months)

Scheduling (Day/Weeks)

Real Time Dynamic Optimization - DQP (hr)

App -1
App -2
App -3
App -n
Plant-wide Optimization

Refrinery Model – An APC View

APC model has a greater resolution but limited scope
- It captures essential unit or area operating constraints
- Optimizes unit production to possible detriment of plant
The model has a high level of abstraction

- It captures essential material and energy balances in holistic view of the refinery
- It leaves out many unnecessary or even obscuring details for the economic optimization
Profit Executive is the “Integration Scheme”

A copy of yield model + economics from planning/scheduling

Returned values can include the predicted yields and proxy limits

Manage intermediate and final:
- Inventory (volumes)
- Properties (quality)
- Timeline (just in time)

Manage:
- Unit operation
- Limits
- Constraints

Profit Executive is the “Integration Scheme”

Honeywell
Profit Executive Components

Planning

Optimizer
What-If steady state analysis using current operating conditions

Controller
Dynamic operating plan moves provided to simulator

Execution

Optimizer
Generates optimal steady state operating plan based on actual costs

Controller
Moves plant toward optimal while accounting for immediate constraints

Predictor
Computes yield/property model biases using operating data

APC Extensions
Bounds optimization problem based on APC constraints
UOP-HPS Integrated Solutions for APC
Process Models Example - Hydrocracking

System data
- Process data
- Lab data
- Online analyzers

Performance Calculations
- Mass balance
- Catalyst space velocity
- Catalyst life
- Catalyst average bed temperatures
- %HDS, %HDN, gross and net conversion
- H2 consumption
- H2 partial pressure
- As-produced product yields
- Product yields at standard cut points
- Product TBP cut points

Process models
- Yield
- Activity
- Deactivation
- Product quality

Economically optimize manufacturing complex:
- Unit product rates
- Unit product qualities
- Provides operating responses for optimum

Practical constraints:
- Catalyst temperatures
- Equipment design
- Cycle length

Leverages process expertise for attainable optima
Optimization Case Studies
Multi-unit Optimization Case Study

- **Profit**: Optimizer coordinates Profit Controllers (APC controllers) to maximize profit by solving collaborative optimization problem.
- **Scope**: coordinate Profit Controllers of FCC and HFA units.
- **Optimization task**: maximize most valuable product yield for different scenarios (gasoline / alkylate / propylene) with compliance to each Profit Controller constraints.

![Diagram showing Production plan and Optimization target with Profit Optimizer (DQP) and Profit Controllers-1, 2, 9 connected.]
Multi-unit Optimization Case Study

FCC Reactor Temperature

Date

01.03.2014 28.03.2014 07.04.2014 15.04.2014 22.04.2014 01.05.2014 14.05.2014

°C

530.0 532.0 534.0 536.0 538.0 540.0 542.0 544.0

Gasoline Butane-butene Gasoline Propylene Profit
## Multi-unit Optimization Case Study

<table>
<thead>
<tr>
<th>Optimization scheme</th>
<th>Results (change of yield % to FCCU feed)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximize gasoline yield</td>
<td>+0.6% gasoline</td>
<td>Constrains: propylene yield, butan-butylene yield, gasoline RVP, gasoline RON, olefins in butan-butylene, min T of reactor</td>
</tr>
<tr>
<td></td>
<td>–0.2% propylene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>–0.3% alkylate</td>
<td></td>
</tr>
<tr>
<td>Maximize propylene yield</td>
<td>+0.15% propylene</td>
<td>Constrains: gasoline yield, max T of reactor, gas plant capacity</td>
</tr>
<tr>
<td></td>
<td>+0.05 % alkylate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>–0.1% gasoline</td>
<td></td>
</tr>
<tr>
<td>Maximize alkylate yield</td>
<td>+0.4% alkylate</td>
<td>Constrains: gasoline yield, max T of FCC reactor, max T of HFA reactor, alkylation capacity</td>
</tr>
<tr>
<td></td>
<td>–0.6% gasoline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>propylene – no change</td>
<td></td>
</tr>
<tr>
<td>Net profit maximization</td>
<td>78 000 Rubbles per day, (= 28 mln. Rubbles per year)</td>
<td>Constrains: all above</td>
</tr>
</tbody>
</table>
Plant-wide Optimization Case Study

Gate-to-gate optimization of oil refinery distillate production

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Average crude saving is ~ 0.5% for meeting the same product demand.

This is worth $22M/year

Feed Cost Saving from Optimizing the Volumetric Gains
Pursue Profit with Honeywell’s Profit Suite

**Layered Optimization**
Honeywell’s unique solution for leveraging existing models and increasing operator effectiveness while driving max benefits through large-scale optimization

**Unified Technology**
Single platform from Experion-embedded to plant-wide control & optimization

**Faster Realization of Benefits**
Designed for minimal effort to achieve the first Euro of benefits and build to larger benefits as ROI is justified

**Flexible Licensing**
Honeywell’s flexible approach to software licensing ensures maximum returns and protection of your investment

**More Benefits Over Time**
The most comprehensive offering to transform business needs and objectives into real-time operations
Questions?

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